Impact of Three Dimensional Data Assimilation on High Resolution Weather Forecasting in the Los Angeles Basin

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Outline

- IR&D study objectives
- Modeling system description
- Preliminary data impact results
- Future work

Internal Research & Development (IR&D) Study Objectives

- Improve the high-resolution capability of MM5 numerical weather prediction model through optimal assimilation of space based and local data sources
- Demonstrate automated daily 36 hour forecasts over the LA basin forecasts at high (3-5)km resolution
  - AQ predictions
  - Terrorist threat emergency response
- Access accuracy of model forecasts through quantitative and qualitative verification

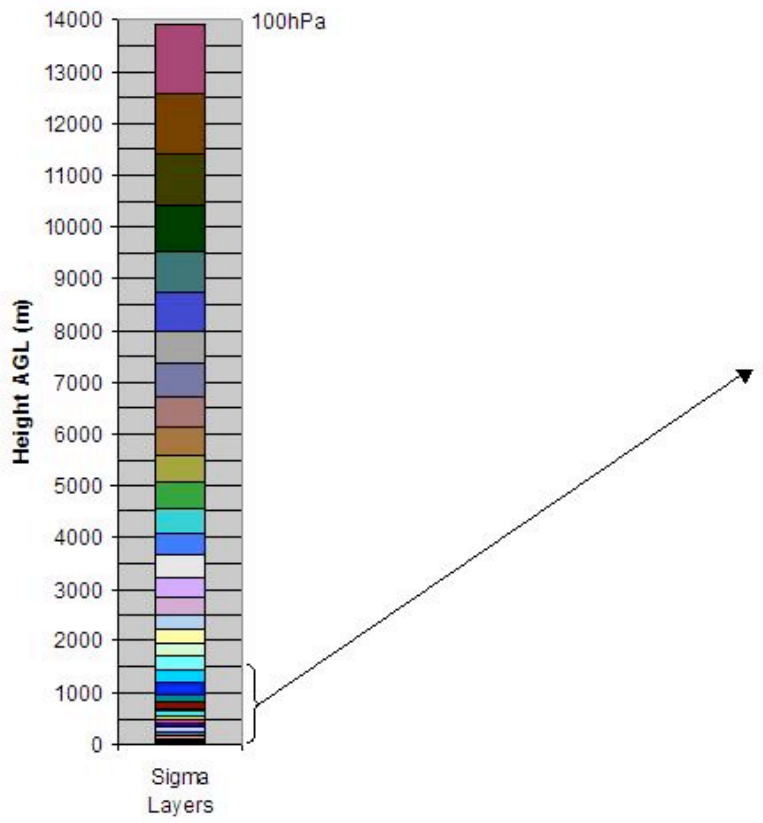
Modeling System Description

- Software
  - 3-Dimensional Variational Analysis System (3DVAR)
    - Ability to assimilate a wide variety of observations, especially parameters other than model state variables (e.g., satellite data)
    - Data assimilation cycle employed for each domain
    - Background errors computed for each domain
  - MM5 Version 3.5
    - Cumulus parameterization (Grell) in just the outer domain
    - Long and short wave radiation scheme with cloud radiative cooling
    - Mixed phase (Reisner) cloud micro-physics
    - Multilayer soil temperature model
    - MRF planetary boundary layer (PBL) scheme
    - 37 vertical (half-sigma) levels with the top of the model at 100 hPa
  - Post-processing and verification
- Hardware
  - Cray SV1
  - SGI Onyx
- Initialization data

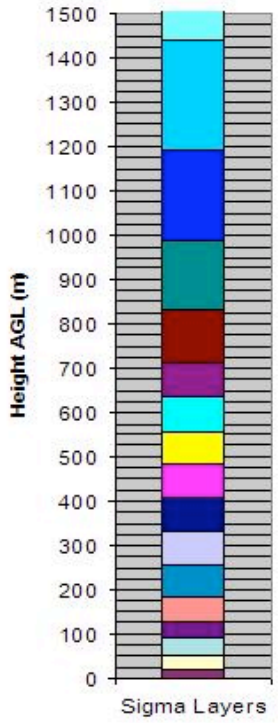
Model Levels

Vertical Levels Used in MM5

37 vertical (half sigma) levels
Sfc – 14,000m = 100hPa



Detail Below 1500 meters



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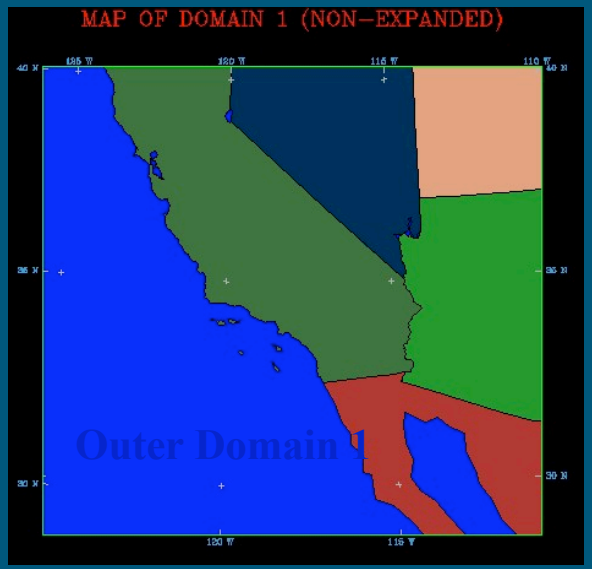
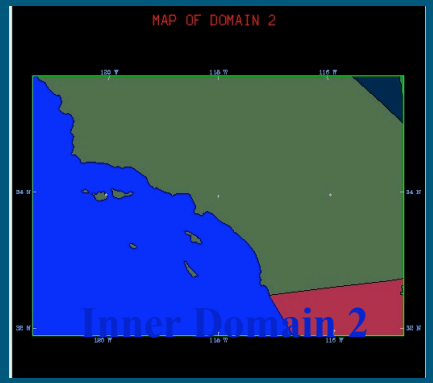
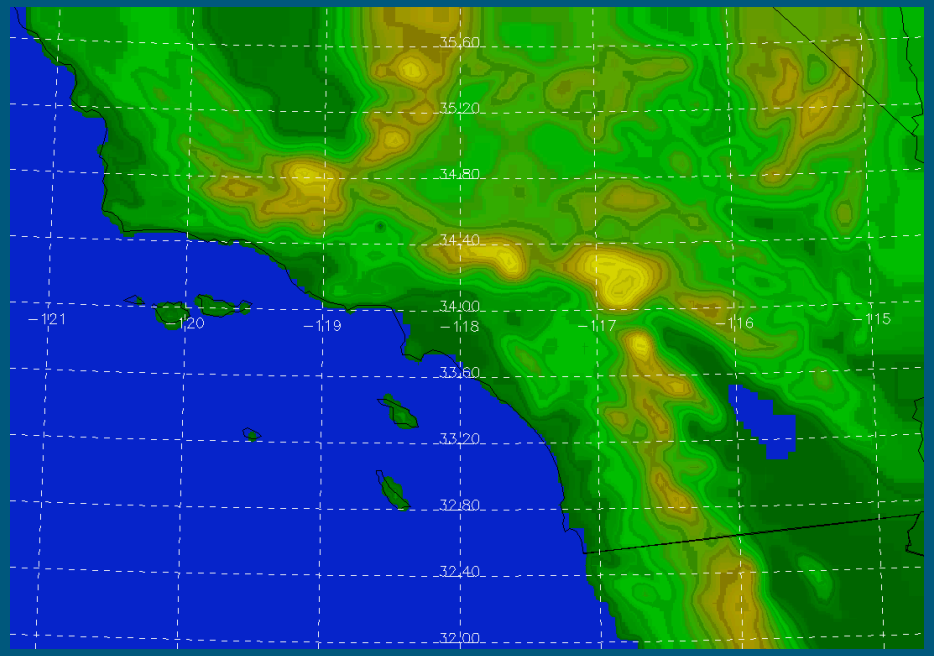
Model Domains and Terrain

	Grid Size	Lat Min	Lat Max	Long Min	Long Max
Outer Domain 1	15km	28.6	40.1	-126.1	-109.7
Inner Domain 2	5km	31.9	35.7	-121.3	-114.6







Terrain of Inner Domain

- Mounts Pinos, San Jacinto, and San Gorgonio are prominent
- Palos Verdes peninsula, and Catalina and other islands are also resolved

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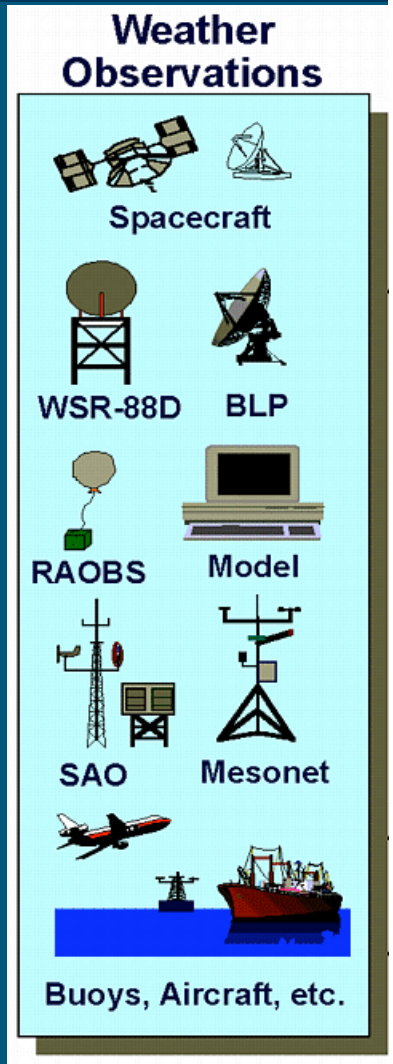
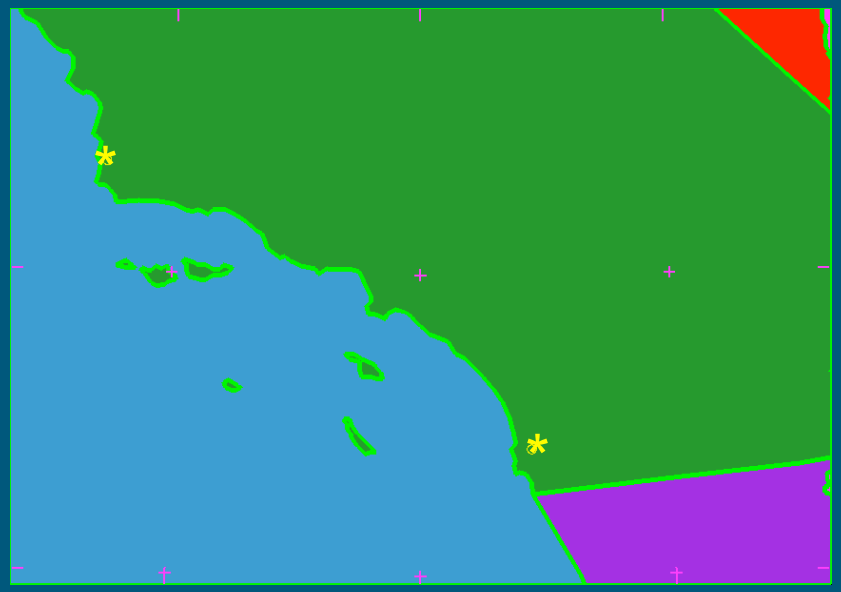
Initialization Data

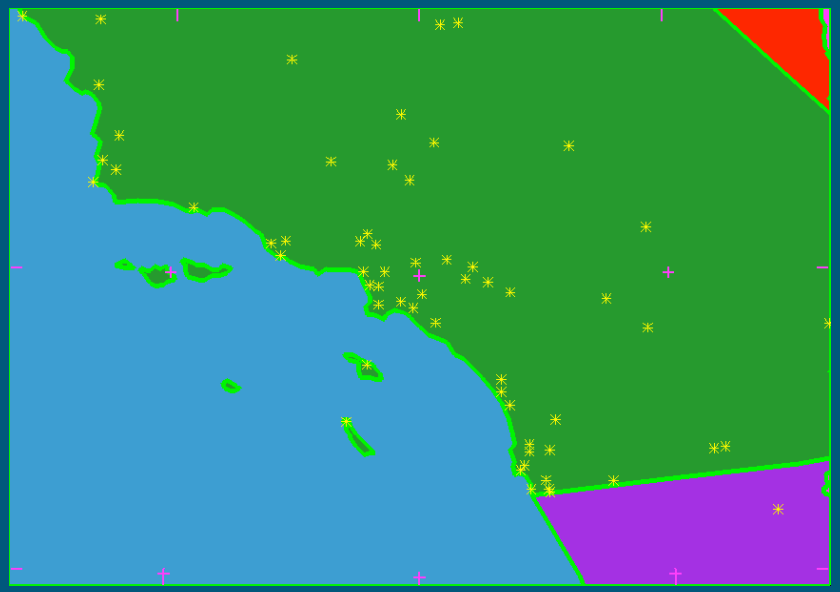
- Observations
  - Surface Data
    - Conventional NWS and DoD surface reports (including ships,buoys)
    - SCAQMD Meteorological observations
    - Bureau of Land Mgmt Remote Automated Weather Obs (RAWS)
    - Additional buoys from the NBDC
  - Profile Data
    - Boundary Layer Profilers (Wind)
    - RASS Profiles (Temp)
    - Aircraft Reports (Aireps)
    - Radiosondes
  - Satellite Data
    - GOES Cloud Drift Winds
    - DMSP SSMI Total Precipitable Water and Ocean Sfc Wind speed
    - Quikscat Wind Speed and Direction
    - GPSMet Total Precipitable Water
- Boundary/Background Field Sources
  - ETA Initial conditions (40 Km grid spacing)
  - MM5 6-h forecasts (15 & 5 km grid spacing)
  - NAVY Sea Surface Temperatures



Nationally Available Observations

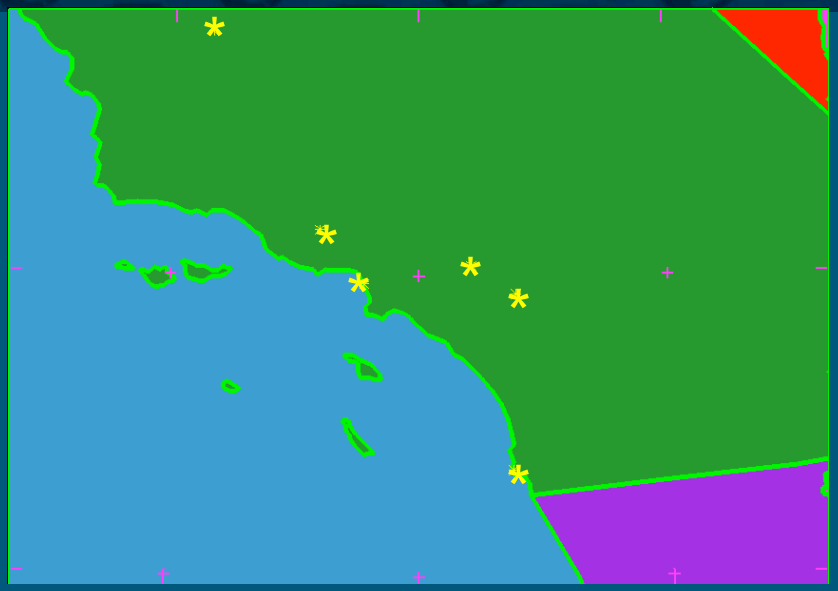


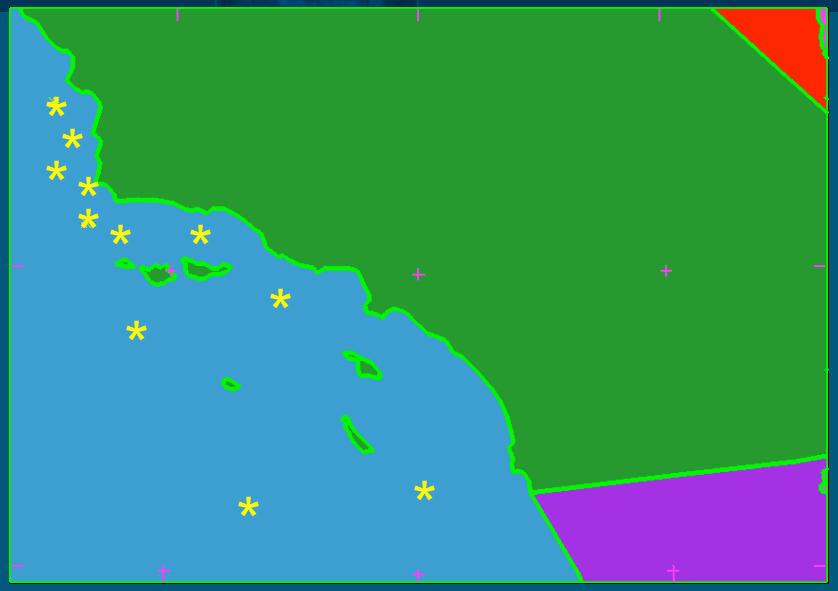
Nationally Upper Air (Profiles) Observations

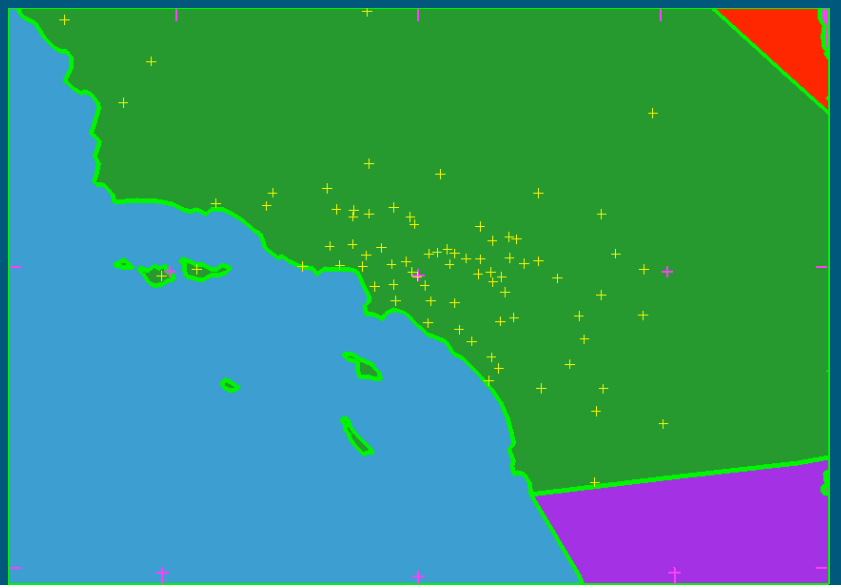


Nationally Available Surface Observations

Locally Available Profiles, Surface and Buoys Observations







Boundary Layer Winds and Temperature Measurements from Wind Profilers and Radio Acoustic Sounding Systems

SCAQMD Surface Meteorological Observations and BLM RAWs

Buoys via the NBDC

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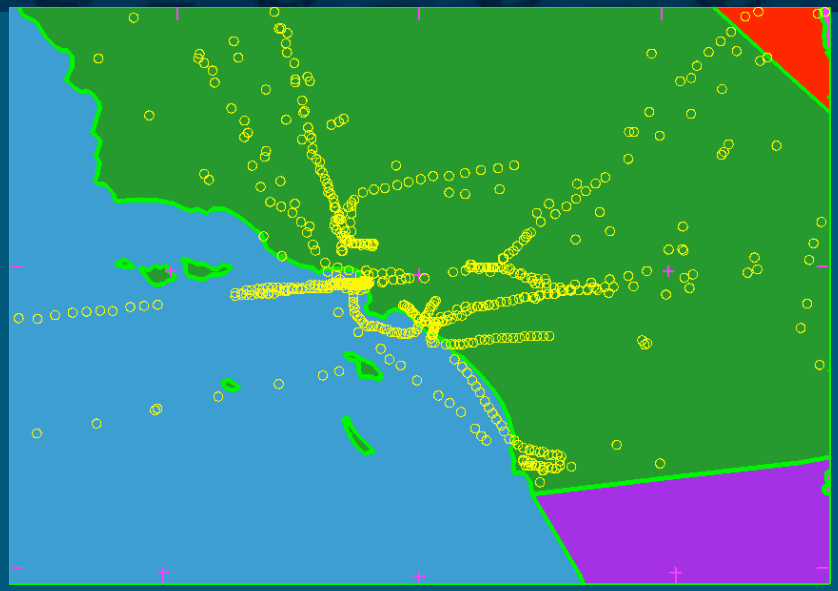
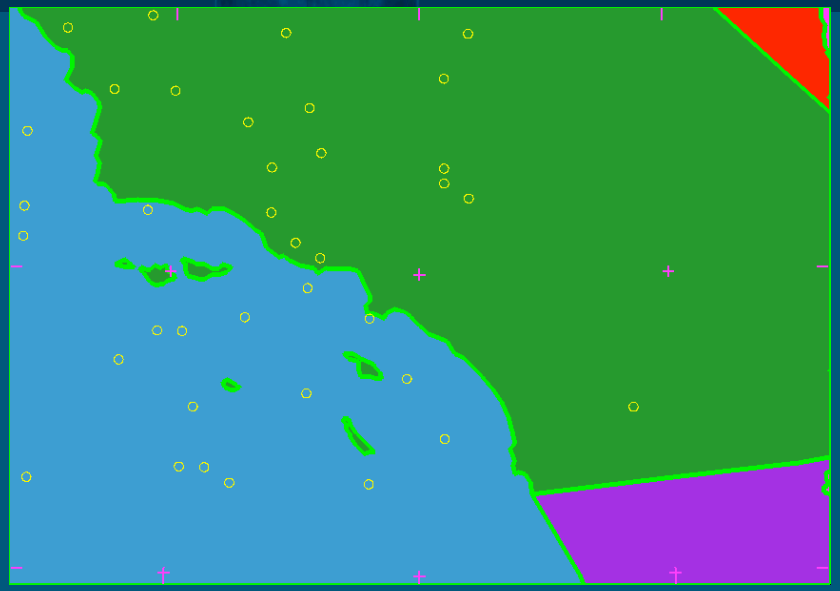
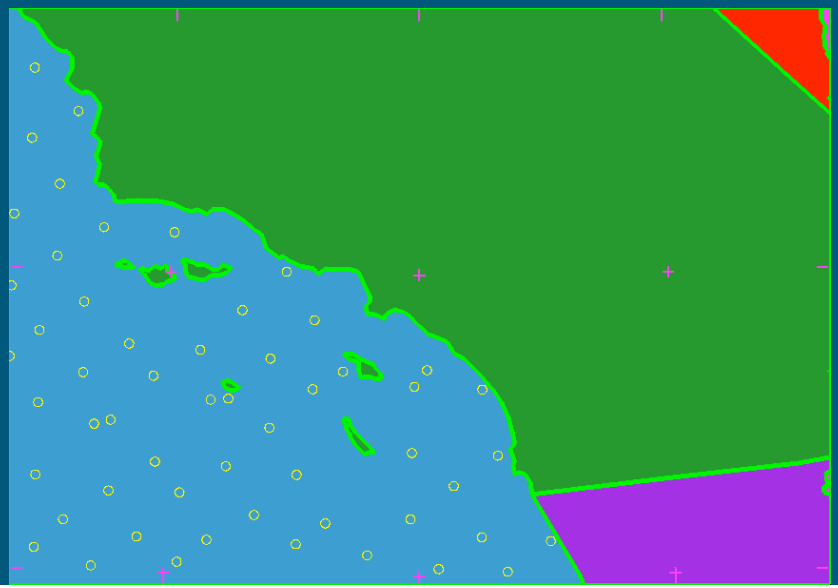
Unconventional Observations



Temperature and Wind Reports from Aircraft



Wind Reports Derived from Cloud Motion Detected by Geostationary Weather Satellites



Remotely Sensed Ocean Surface Wind Speed and Total Columnar Water Vapor from SSMI

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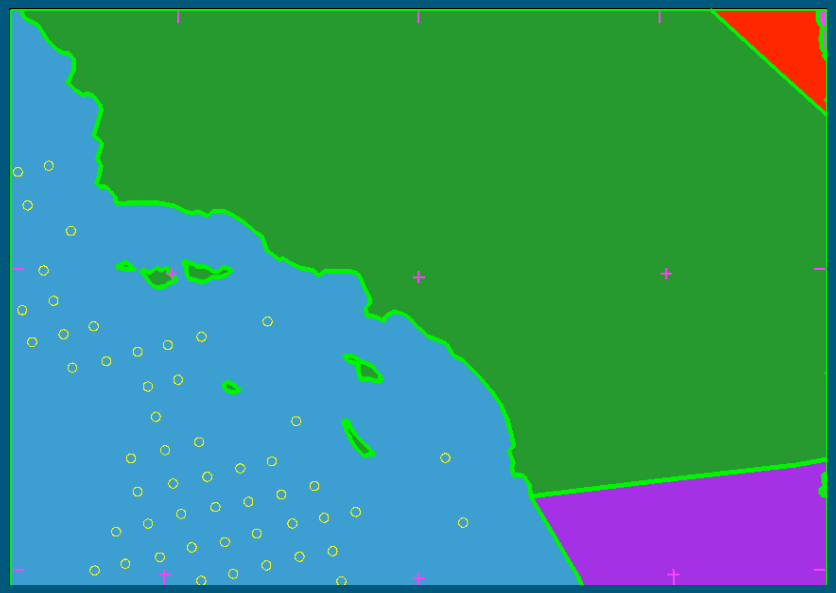
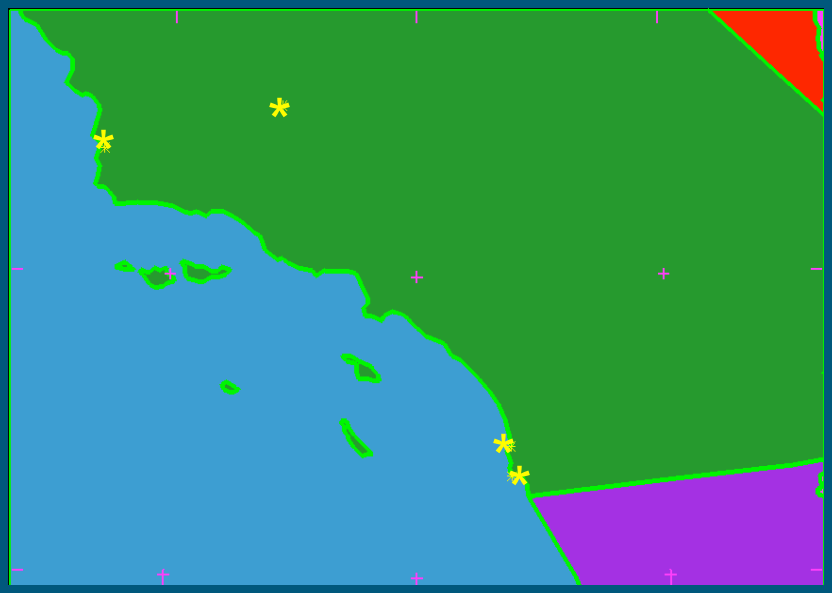
Unconventional Observations

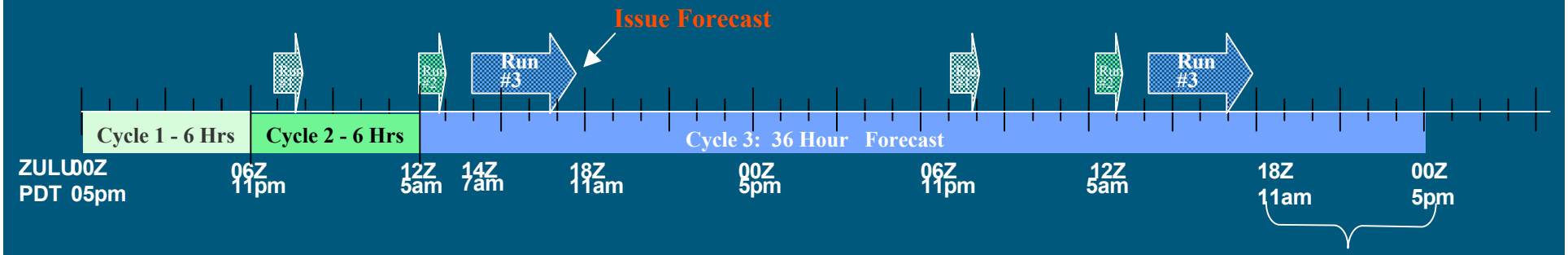


QuikScat Wind Direction
and Speed Reports



GPS TPW Observations

Model Concept of Operations

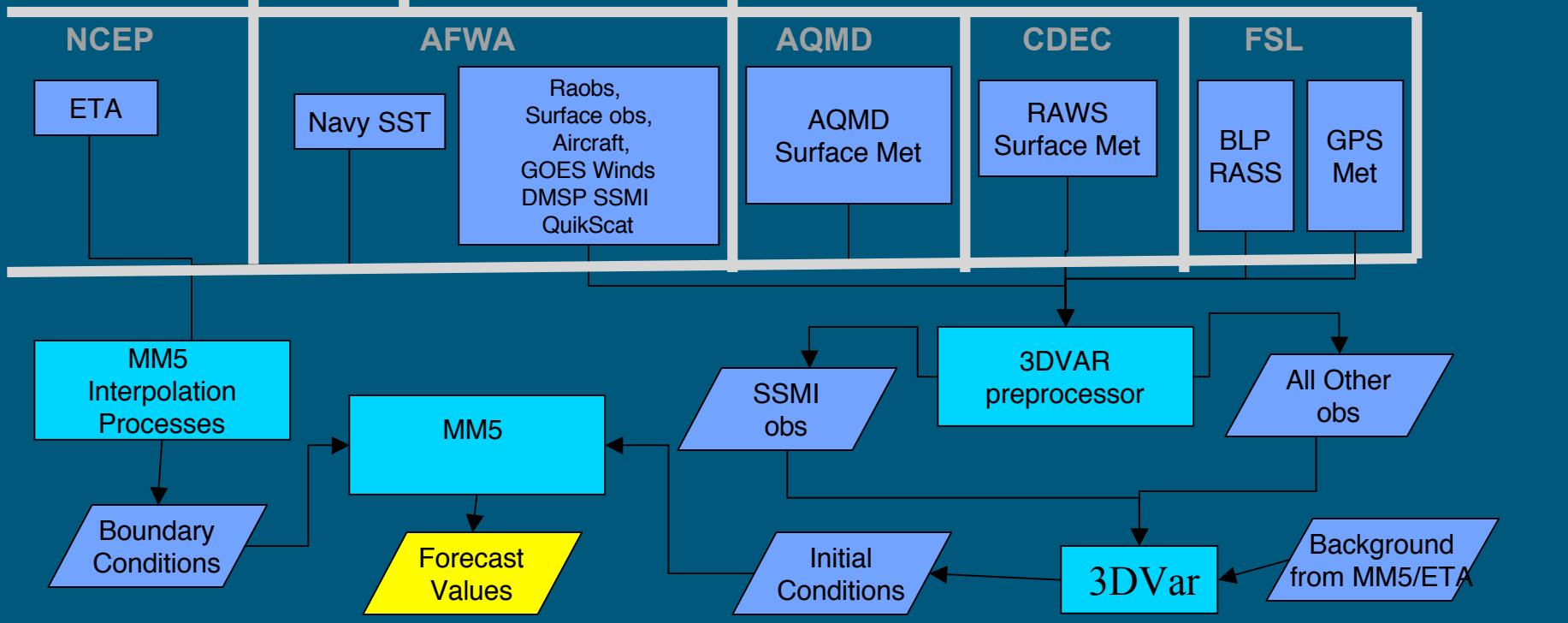


Cycle 1: Pull ETA 00Z out 6hrs
Cycle 2: Pull ETA 06Z out 42 hrs

Daily at 12Z for previous day

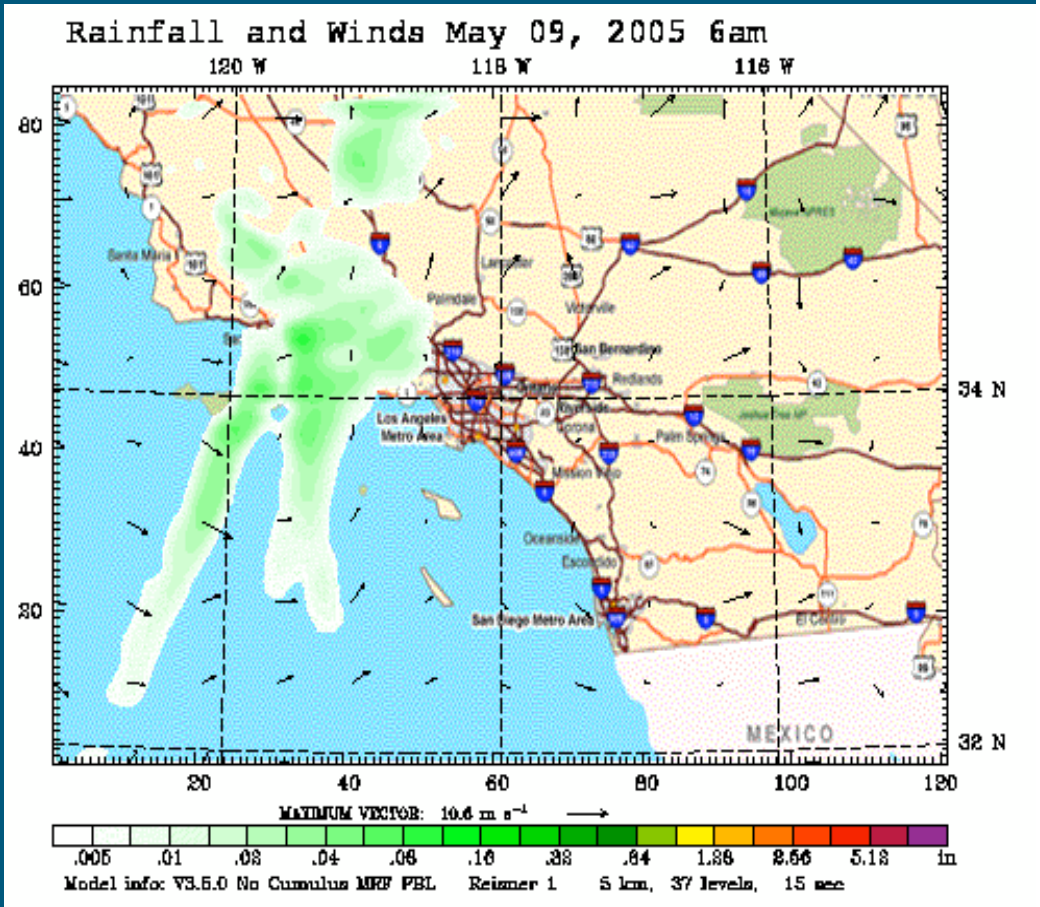
Cycle 1: Pull 00Z obs at 05:50Z
Cycle 2: Pull 06Z obs at 11:50Z
Cycle 3: Pull 12Z obs at 13:30Z

Hourly



Automated Distribution of Products

- Model forecast plots available daily ~ 1pm at www.aerospaceweather.com
- Verification plots posted as the data catches up with forecast period (~ 2 days after the run)
- Binary data shipped to an external FTP site daily (aerospace.aero.org)



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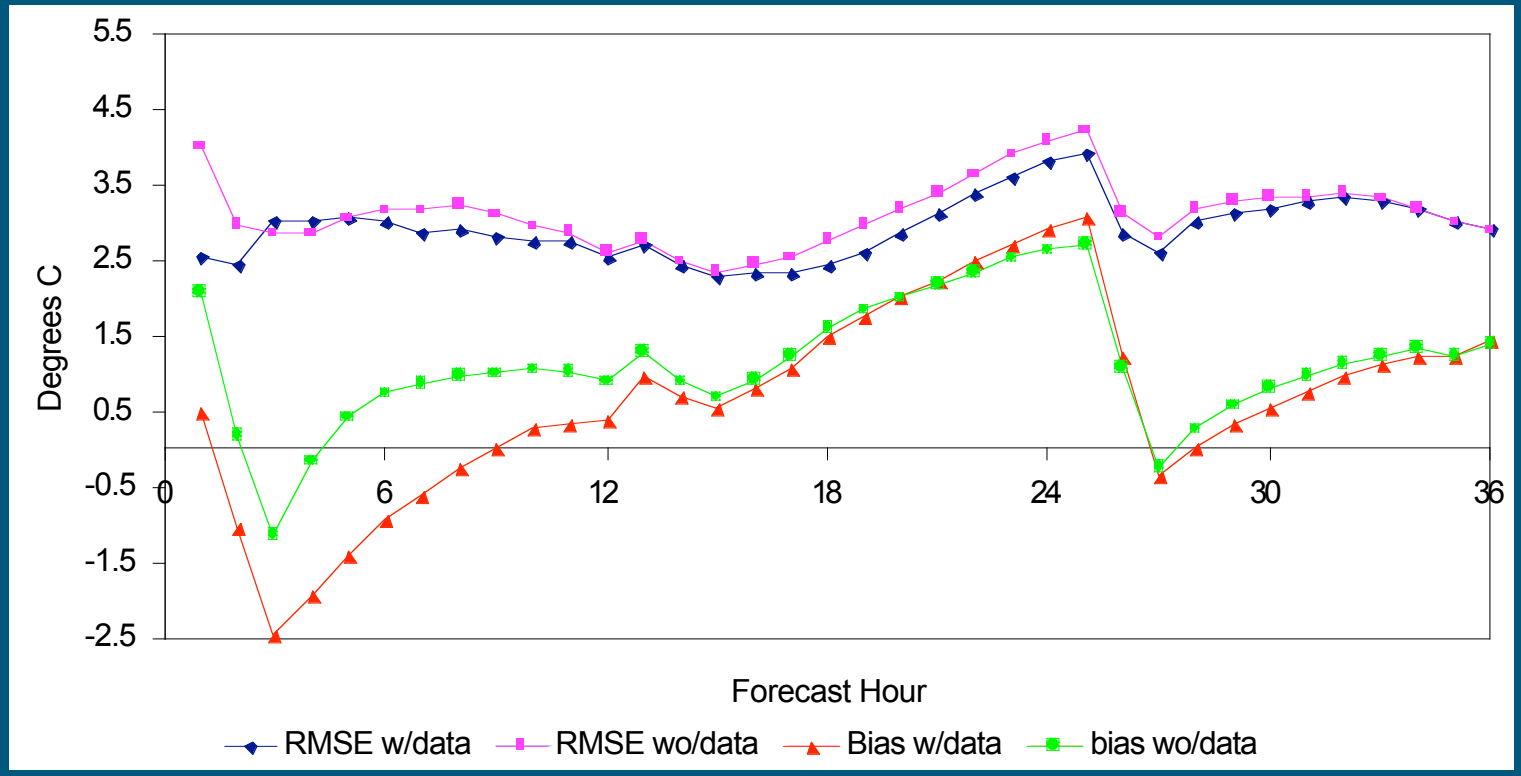
Data Impact Study

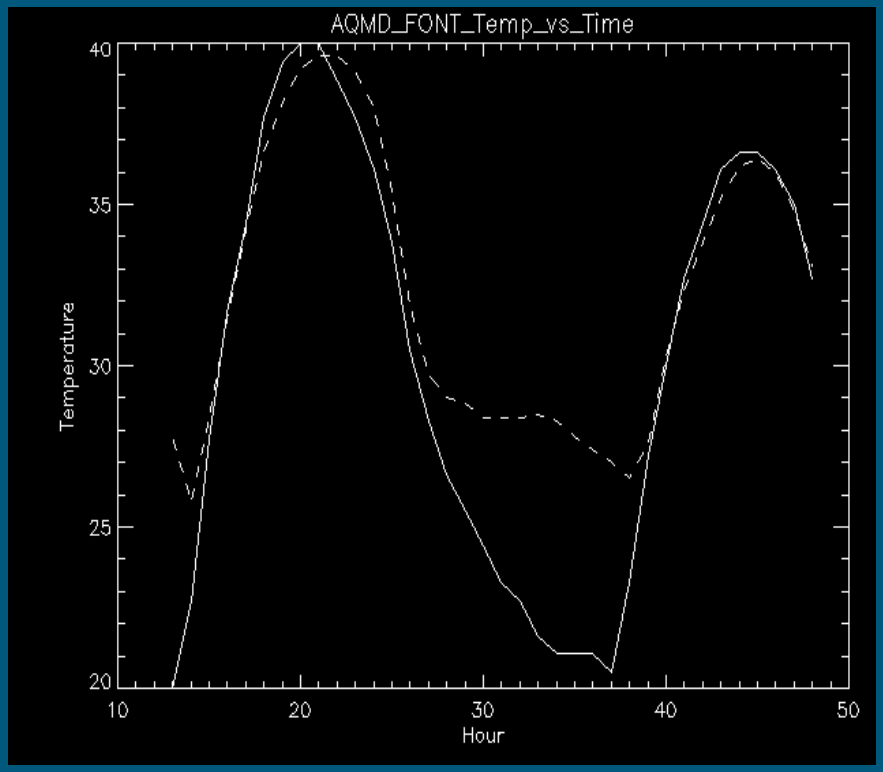
- Forecasts from the operational run (with local data assimilation) are compared to forecasts initialized with Eta model data (without local data assimilation)
- All data impact verifications are for Domain 2
- Forecast verification were done for 21 days over the period 31 Aug 2004 to 29 Sep 2004
- Hourly bias and RMS error computed for each case
- Initial verification done versus SCAQMD surface stations

Impact on Meteorological Forecasts

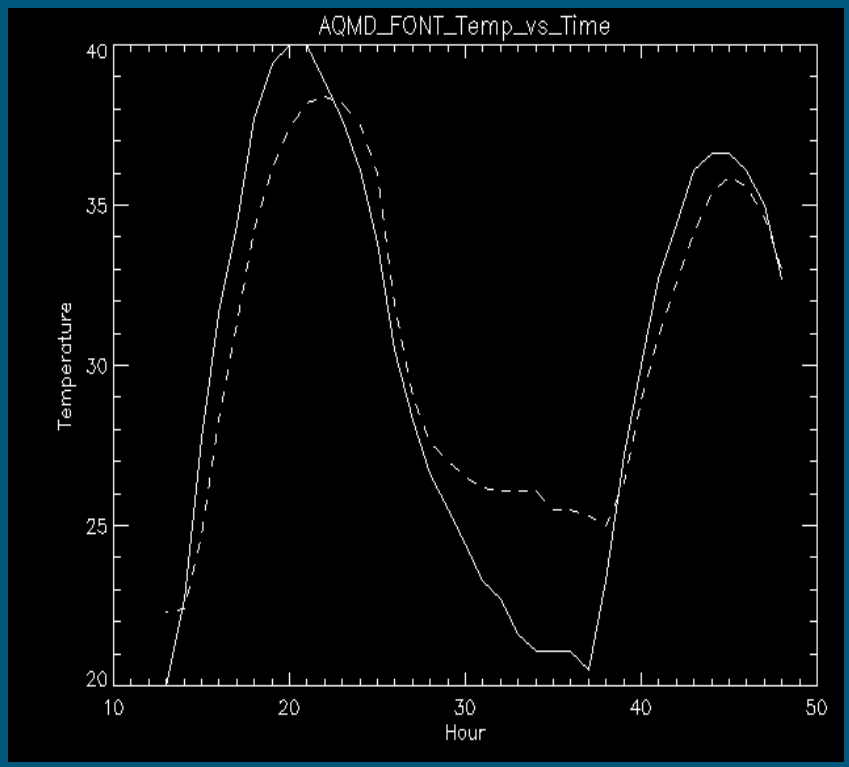


Hourly Root Mean Squared 2-meter temperature forecast error and bias using AQMD surface stations as truth data for the with (w/data) and without (wo/data) local data assimilation cases

Impact on Meteorological Forecasts



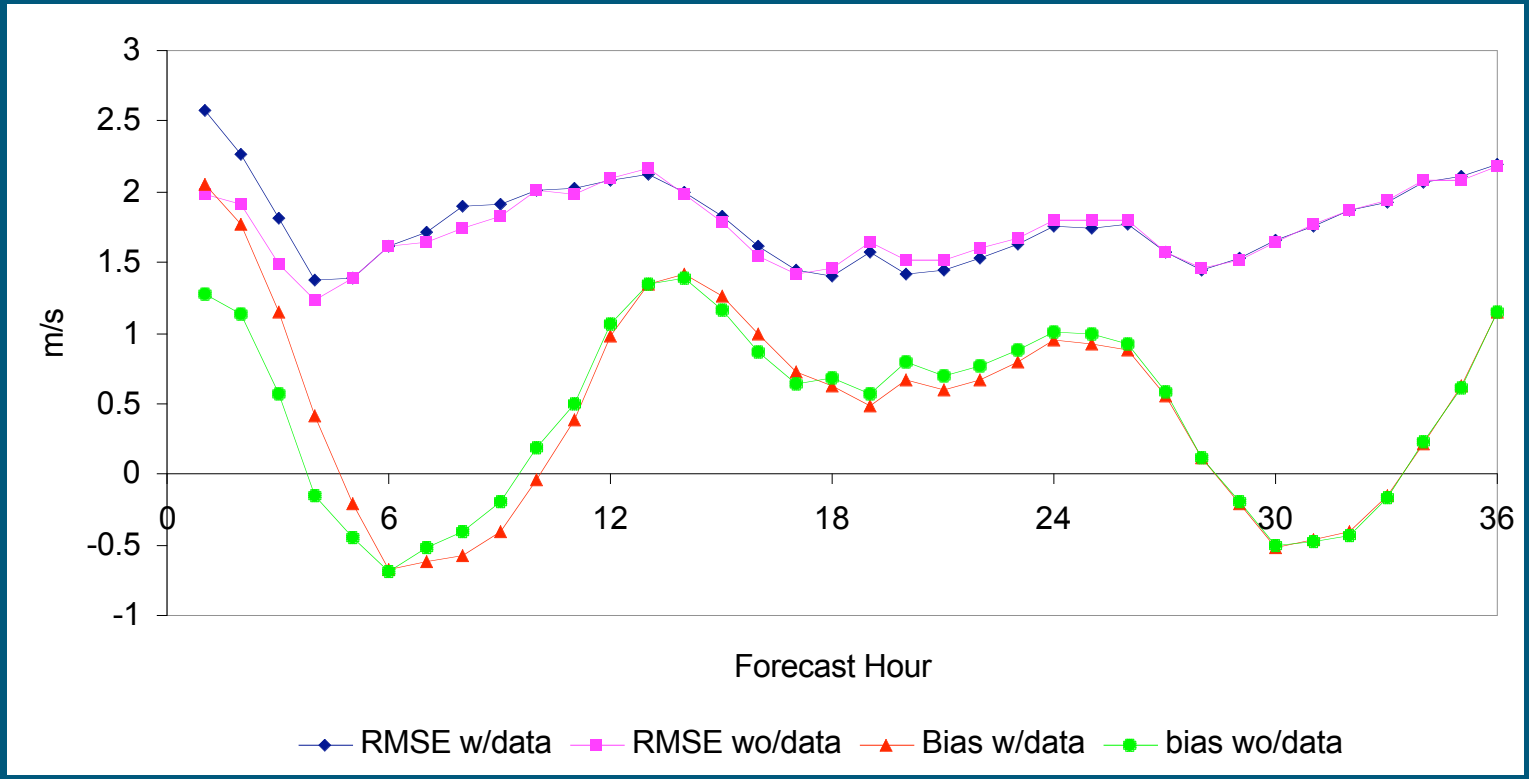
(a)



(b)

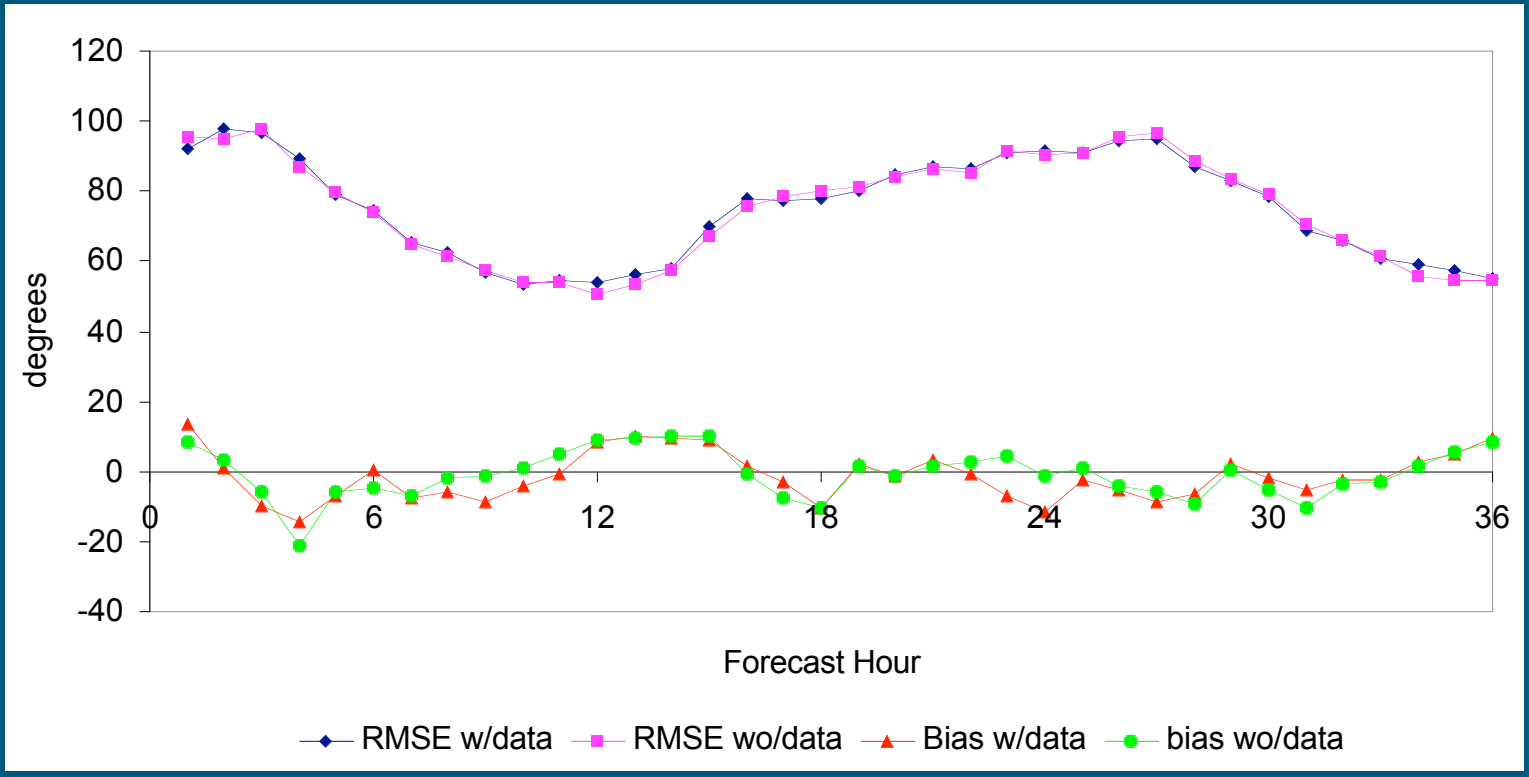
Time series of predicted (dashed line) and observed (solid line) at Fontana CA for the without (a) and with (b) local data assimilation cases

Impact on Meteorological Forecasts



Hourly Root Mean Squared 10-meter Wind Speed forecast error and bias using AQMD surface stations as truth data for the with (w/data) and without (wo/data) local data assimilation cases

Impact on Meteorological Forecasts



Hourly Root Mean Squared 10-meter wind direction forecast error and bias using AQMD surface stations as truth data for the with (w/data) and without (wo/data) local data assimilation cases

Preliminary Conclusions

- Data impact on 2-meter temperature is largest in the first few hours of the forecast but there is positive impact out to 24 hours
- Use of the same boundary conditions for the outer domain eventually "drive" the inner domains of both cases to a similar solution
- The impact on the 10-meter wind forecasts are questionable at this point in time
  - There appears to be no significant impact on 10-meter wind direction forecasts
  - The impact on the 10-meter wind speed forecast is slightly negative and the impact diminishes quickly with time (little or no impact after 6 hours)

Future Work

- Extend calculation of background error statistics for the LA Basin
- Finish data impact analysis
  - Comparisons versus boundary layer profilers and other observation sources
  - Subjective verification of selected days during the period
- Establish a continual data assimilation cycle
- Couple the MM5 with a more sophisticated Land Surface Model (LSM)
- Use higher resolution SST